4r·9. For this purpose simultaneous observations were made with the ordinary micrometers, and with the four supplementary micrometers, the latter being presumably free from error. The observations with the ordinary micrometers were reduced with the runs derived from these worn screws as in the ordinary course of work, and the observations with the supplementary micrometers were reduced with the runs from their own screws. By the comparison of the two sets the curve was laid down, "the ordinates of which give the corrections to the circle-reading corresponding to the revolutions and tenths of Microscope A" (*Monthly Notices*, vol. xxxvii. p. 19).

There is no oversight in this. The method was adopted advisedly with the object of determining, not the actual errors of the micrometer screws, but the corrections to the circle-readings on account of these errors. The determination of the actual errors has no practical importance, and could not have been accomplished without special apparatus and a serious interruption to the regular observations. And even if the actual errors had been determined it would have been necessary to correct the runs as well as the micrometer-readings for every observation, and these two corrections would together be equal to the single correction actually applied.

There may, however, be a small effect from error in the runs, if the runs be taken at different parts of the screws. I have expressly referred to this in my paper of 1876 as probably explaining a small difference between the errors at 0r and 5r in 1868 and 1875 respectively. Since the correction for runs is adopted from a considerable number of determinations extending usually over a fortnight, it may safely be assumed that the adopted run will apply sensibly to the same part of the screws.

As regards the other remarks which Mr. Stone makes on the alterations of Bessel's Refractions, I do not find that he has brought forward any new points which call for further notice after the somewhat lengthy discussions of Bessel's constant and law of refraction contained in my two previous papers on the subject.

*Blackheath:*
1881, *May.*

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## *On the Supposed Difference in the Refractions North and South of the Zenith of Melbourne.* By A. M. W. Downing, Esq.

In the *Monthly Notices* for December 1867 there is a paper by Mr. Stone "On Bessel's Mean Refractions," containing (amongst other things) a discussion of the North Polar Distances of stars observed at Melbourne during the years 1863, 1864, and 1865. As the result of this discussion it appeared that from the North Polar Distances of stars observed above and below the pole, the refractions of the *Tabulæ Regiomontanæ* should be diminished by 0·00372 × Refraction; whilst from the comparison

of Greenwich and Melbourne results it appeared that, to the north of the zenith the tabular refractions should be diminished by 0·00914 × Refraction, to satisfy the Melbourne observations. The correction to the adopted co-latitude, corresponding to the above diminution of the tabular refractions derived from the observations of circumpolar stars, was $+0''\cdot149$. These results were actually used in the reduction of the observations of stars whose places are given in the First Melbourne General Catalogue for the epoch 1870, it being assumed that the mean refractions were really different north and south of the zenith. A discussion of the same Melbourne observations by Prof. Gyldén (*V. J. S.* Bd. iv. Heft 2) was considered to be confirmatory of Mr. Stone's results, and also showed that* "a similar discrepancy was apparent in the Cape of Good Hope and the St. Helena observations, thus indicating the cause to be a general one." With regard to the Cape of Good Hope observations, it must be remarked that Prof. Gyldén's investigations only refer to the observations made with the old Mural Circle, and that Mr. Stone has shown (*Monthly Notices*, Dec. 1879) that, as far as the observations made under his direction are concerned, there is no sensible difference between the mean refractions north and south of the zenith, the observations on both sides being very fairly represented by Bessel's Refractions unaltered. And I have no doubt that if a first-class Transit Circle were erected on the site of Johnson's Observatory at St. Helena, we should have very similar results.

My attention was drawn to the large correction which has been applied to the refractions of the *Tabulæ* in the formation of the N.P.D.'s of the Melbourne Catalogue for stars north of the zenith by finding, from a discussion of the star places of the Catalogue (*Monthly Notices*, Jan. 1879), that the N.P.D.'s of stars passing the meridian near the north horizon appeared to be systematically too large, and therefore that the adopted refractions were too small. The same thing appears from a comparison of the Melbourne and Washington observations made by Mr. Lewis Boss ("Declinations of Fixed Stars," p. 67), from which he finds that the refractions of the *Tabulæ* must be diminished by 0·00733 × Refraction to satisfy the Melbourne observations. (With regard to the assumption of a difference in the refractions north and south of the zenith, Mr. Boss aptly remarks that, "though possible on *a priori* grounds, this hypothesis is open to serious objections, when we consider the difficulty of determining the correction to the adopted refractions independently at the latitude of Melbourne.") There cannot be much doubt, therefore, but that the correction applied to the stars on the north side, derived from the observations made 1863–1865, is too large to satisfy the observations made during the whole period 1863–1870, the results of which are embodied in the Melbourne Catalogue. Under these circumstances it becomes a matter of interest and importance to investigate the subject in as complete a manner as

* Introduction *Melbourne Cat.* p. iv.

the available materials render possible; and I have therefore not hesitated to avail myself of the opportunity for entering on the discussion presented by the publication of another volume of Melbourne Astronomical Results.

This volume (the fifth of the series) contains the results of observations made during the years 1871–1875, both inclusive. The instrument and methods of observing remain substantially unaltered, and therefore need no detailed description here. It may, however, be remarked that special attention has been paid to the observation of wide circumpolars, and of stars passing the meridian near the north horizon, for the purpose of determining the refraction both to the north and to the south of the zenith. There is unfortunately no provision for the observations of stars by reflexion. This is a most serious omission, and must greatly diminish our confidence in the Melbourne results. Reflexion observations are most essential, both for the accurate determination of zenith points (in combination with the nadir observation), and also for detection of systematic errors in the circle-readings, whether these arise from uncorrected flexure or other causes. I hope that before long we shall have reflexion observations made regularly and uninterruptedly at Melbourne.

With regard to the horizontal flexure, it is stated in the Introduction to this volume that its amount was determined, by the method of opposing collimators, once a week from the beginning of 1871 to the end of 1874, and once a month during 1875; a mean value was used for the interval between the observations, as in the case of the runs. It is unfortunate that no table of these observations, or of the results derived from them, is given, so that we have no information as to the stability or otherwise of this important correction. Those who are concerned with the printing of astronomical observations would do well to remember that it is very desirable that all matters relating to the adjustment or stability of instruments should be given in considerable detail.

I now proceed to the discussion of the observations of circumpolar stars contained in this volume. The places of the stars as found from each year's observations have been taken from the Annual Catalogues, and reduced to a common epoch 1873·0, the results for upper and lower transit being of course kept separate; mean places have then been computed for each star for 1873·0, and the difference N.P.D. at upper transit *minus* N.P.D. at lower transit found. The stars have next been arranged in order of N.P.D., and divided into groups, each group embracing about 5° of N.P.D. The results of each group have been combined, so that corresponding to a definite N.P.D. we have a definite discordance, and for the purposes of the present investigation it is assumed that these discordances arise from error in the adopted co-latitude, and error in the adopted refraction. The co-latitude adopted in this volume is that originally found for the Melbourne Observatory—viz. 52° 10′ 6″·6—and the refractions used are those of Bessel's *Tabulæ Regiomontanæ* unaltered. The weights

assigned to the places of individual stars are found from the expression for the probable error of a Melbourne result given by Prof. Gyldén in the paper referred to above (*V. J. S.* Bd. iv. 102), viz. :—

$$\epsilon^2 = (0{\cdot}26)^2 + \frac{1}{n}\left\{0{\cdot}263 + 0{\cdot}0467\left(\frac{\text{refr.}}{100}\right)^2\right\},$$

where $n$ is the number of observations on which the result depends. The weight of a discordance N.P.D. upper *minus* N.P.D. lower for a single star is

$$w = \frac{1}{\epsilon_U{}^2 + \epsilon_L{}^2},$$

and the weight to be assigned to a group

$$W = \Sigma w.$$

The following table gives the discordances and the corresponding N.P.D.'s found in the manner just described; and I have added for comparison the results obtained by applying the corrections found by MM. Stone and Gyldén from their discussion of the observations 1863–1865.

Mr. Stone's corrections are given in a tabular form in the Introduction to the Melbourne Catalogue, p. v. Prof. Gyldén's definitive corrections are—

$$\delta c = -0''{\cdot}16$$
$$\kappa = -0{\cdot}00314$$
$$\delta\beta = -0''{\cdot}783,$$

where $\delta c$ is the correction to the adopted co-latitude, $(1+\kappa)$R is the true refraction (R being the adopted value), and $\delta\beta$ the correction to the adopted horizontal flexure. A table of these corrections is given by Prof. Gyldén (*V. J. S.* Bd. xi. 184) from which the requisite quantities have been taken.

| | N.P.D. | No. of Stars. | Upper − Lower. I. | II. | III. | Zenith Distance. Upper. | Lower. |
|---|---|---|---|---|---|---|---|
| | ° ′ | | ″ | ″ | ″ | ° ′ | ° ′ |
| 1 | 177 6 | 32 | +0.44 | −0.42 | −0.82 | 49 16 | 55 4 |
| 2 | 173 7 | 35 | +0.68 | −0.20 | −0.59 | 45 17 | 59 3 |
| 3 | 168 20 | 10 | +0.14 | −0.78 | −1.13 | 40 30 | 63 50 |
| 4 | 162 39 | 7 | −0.18 | −1.21 | −1.54 | 34 49 | 69 31 |
| 5 | 157 12 | 4 | +0.61 | −0.61 | −0.93 | 29 22 | 75 58 |
| 6 | 152 38 | 5 | +0.89 | −0.65 | −0.93 | 24 48 | 79 32 |
| 7 | 148 54 | 5 | +1.43 | −0.61 | | 21 4 | 83 16 |
| 8 | 146 4⅓ | 3 | +3.67 | +0.70 | | 18 14 | 86 5¾ |

I. Results as printed.
II. „ with Stone's corrections.
III. „ with Gyldén's corrections.

If we now assume that

$$\frac{x}{2} = \text{correction to adopted co-latitude,}$$
$$\mathrm{R} = \text{tabular refraction at upper transit,}$$
$$\mathrm{R}\,(1-y) = \text{true refraction at upper transit,}$$
$$\mathrm{R}_1 = \text{tabular refraction at lower transit,}$$
$$\mathrm{R}_1\,(1-y) = \text{true refraction at lower transit,}$$

then our equations of condition are

$$x + y\,(\mathrm{R}+\mathrm{R}_1) = \text{N.P.D. upper} - \text{N.P.D. lower.}$$

In the last group (8) I now substitute for the mean refractions of Bessel's Supplementary Table those of the *Fundamenta* multiplied by the factor requisite to bring them up to the system of the *Tabulæ*, so that the refractions are then all found from the same system. The coefficients of $y$ are computed with barometer and thermometer readings at their mean values for Melbourne; it would be more satisfactory to use the actual readings for the last two groups, but the want of the requisite detailed information renders this impossible.

The following are then the equations of condition:—

| | Equations of Condition. | Weights. | Residuals. |
|---|---|---|---|
| 1 | $x + 148\,y = +0''.44$ | 149 | $-0''.05$ |
| 2 | $x + 153\,y = +0.68$ | 123 | $-0.27$ |
| 3 | $x + 165\,y = +0.14$ | 40 | $+0.33$ |
| 4 | $x + 192\,y = -0.18$ | 25 | $+0.78$ |
| 5 | $x + 242\,y = +0.61$ | 15 | $+0.23$ |
| 6 | $x + 326\,y = +0.89$ | 14 | $+0.34$ |
| 7 | $x + 473\,y = +1.43$ | 14 | $+0.50$ |
| 8 | $x + 724\,y = +4.38$ | 6 | $-1.26$ |

Proceeding to solve these by the method of least squares, I find for the normal equations

$$386\,x + 71431\,y = 218.21$$
$$71431\,x + 16797189\,y = 57332.24,$$

whence

$$x = -0''.311 \pm 0''.203$$
$$y = +0.00474 \pm 0.00097.$$

If $y$ be supposed to be without error, the probable error of $x$ becomes $\pm 0''.092$. The sum of squares of residuals (the weights of course being taken into account) is 44.43.

By discussing all the available observations of circumpolar stars made during the years 1871–1875 in the above manner, we therefore find that the adopted co-latitude ought to be diminished by $0''.16$, and that Bessel's Refractions ought to be diminished by

0·00474 × Refraction. It will be remarked, however, that the residuals are not very satisfactory, and that the observations are affected by a considerable systematic error, not depending on refraction, in the neighbourhood of N.P.D. 165°.

For the purpose of comparison with the Greenwich Nine-Year Catalogue the Melbourne results, for stars which are contained in that catalogue, have been reduced to the epoch 1872·0; and mean places computed as in the case of circumpolar stars. The differences Greenwich *minus* Melbourne have then been found; the Greenwich places being corrected by the quantities given in the Addendum to the Introduction to the Nine-Year Catalogue, so that the refractions are Bessel's unaltered. Proceeding in the same manner as for the circumpolar stars, the results have been combined in groups, the weights for the Greenwich observations being found from the following expression for the probable error of a result

$$\epsilon^2 = (0{\cdot}26)^2 + \frac{e^2}{n},$$

where $n$ is the number of observations, and $e$ is taken from Mr. Stone's values of the probable errors of Greenwich observations at different zenith distances; whilst for the Melbourne observations the formula cited above (in the discussion of the circumpolar stars) has been used. Then for the combination we have

$$w = \frac{1}{\epsilon_G^{\,2} + \epsilon_M^{\,2}}, \text{ and } W = \Sigma w.$$

The following table exhibits the results of this comparison:—

| | N.P.D. | No. of Stars. | Greenwich – Melbourne. I. | II. | III. | Zenith Distance. Greenwich. | Melbourne. |
|---|---|---|---|---|---|---|---|
| | ° ′ | | ″ | ″ | ″ | ° ′ | ° ′ |
| 1 | 41 33 | 3 | +3·72 | −2·99 | +0·72 | 3 2 | 86 13½ |
| 2 | 44 42 | 7 | +2·61 | −1·33 | +0·23 | 6 11 | 83 8 |
| 3 | 47 27 | 8 | +2·47 | −0·37 | +0·41 | 8 56 | 80 23 |
| 4 | 50 55 | 7 | +1·22 | −0·85 | −0·53 | 12 24 | 76 55 |
| 5 | 57 20 | 6 | +0·87 | −0·47 | −0·56 | 18 49 | 70 30 |
| 6 | 62 14 | 20 | +1·08 | +0·06 | −0·19 | 23 43 | 65 36 |
| 7 | 67 31 | 13 | +1·37 | +0·59 | +0·21 | 29 0 | 60 19 |
| 8 | 72 20 | 9 | +1·27 | +0·65 | +0·21 | 33 49 | 55 30 |
| 9 | 76 59 | 16 | +0·90 | +0·40 | −0·08 | 38 28 | 50 51 |
| 10 | 82 7 | 16 | +0·56 | +0·16 | −0·34 | 43 36 | 45 53 |
| 11 | 87 24 | 16 | +0·48 | +0·18 | −0·34 | 48 53 | 40 26 |
| 12 | 92 47 | 9 | +0·01 | −0·21 | −0·73 | 54 16 | 35 3 |
| 13 | 98 25 | 11 | +0·60 | +0·45 | −0·06 | 59 54 | 29 25 |
| 14 | 102 51 | 4 | +0·52 | +0·42 | −0·06 | 64 20 | 24 59 |
| 15 | 107 9 | 11 | +0·40 | +0·35 | −0·10 | 68 38 | 20 41 |
| 16 | 112 50 | 6 | +0·06 | +0·07 | −0·36 | 74 19 | 15 0 |
| 17 | 117 1 | 8 | +0·04 | +0·09 | −0·30 | 78 30 | 10 49 |
| 18 | 120 18 | 1 | +0·96 | +1·07 | +0·67 | 81 47 | 7 32 |
| 19 | 124 9 | 1 | −2·10 | +1·99 | +2·31 | 85 38 | 3 41 |

I. Greenwich corrected, Melbourne as printed.

II. " " " with Stone's corrections.

III. " " " with Gyldén's corrections.

Groups (18) and (19) containing only one star in each—viz. *Fomalhaut* and *α Columbæ* respectively—have not been used in the subsequent computation.

Now, if we assume

$$\text{True refraction for Greenwich} = \text{tabular } (1-x) = \text{R } (1-x),$$
$$\text{,, ,, Melbourne} = \text{tabular } (1-y) = \text{R}_1 (1-y),$$
$$\text{Correction for relative error of adopted latitudes} = \delta l,$$

then the equations of condition are

$$\text{R}x + \text{R}_1 y + \delta l = \text{Greenwich} - \text{Melbourne}.$$

The discordances are of course taken from column I. of the table, except that in the case of (1) the result of substituting the mean refractions of the *Fundamenta* brought up to the system of the *Tabulæ* for those of the Supplementary Table has been used; also the Greenwich results have been corrected for assumed error of the thermometer ($+0°.55$). In computing R and $\text{R}_1$ the barometer and thermometer readings are taken at their mean values for the two Observatories. The equations of condition then become:—

| | Equations of Condition. | Weights. | Residuals. |
|---|---|---|---|
| 1 | $3x+723y+\delta l = +5''.22$ | 6 | $-0''.50$ |
| 2 | $6x+444y+\delta l = +2.61$ | 26 | $+0.42$ |
| 3 | $9x+325y+\delta l = +2.48$ | 31 | $-0.22$ |
| 4 | $13x+241y+\delta l = +1.23$ | 36 | $+0.50$ |
| 5 | $20x+160y+\delta l = +0.89$ | 33 | $+0.32$ |
| 6 | $25x+126y+\delta l = +1.10$ | 92 | $-0.10$ |
| 7 | $32x+101y+\delta l = +1.41$ | 65 | $-0.56$ |
| 8 | $39x+83y+\delta l = +1.31$ | 53 | $-0.57$ |
| 9 | $46x+70y+\delta l = +0.95$ | 88 | $-0.28$ |
| 10 | $55x+59y+\delta l = +0.62$ | 94 | $-0.01$ |
| 11 | $66x+49y+\delta l = +0.55$ | 81 | $+0.01$ |
| 12 | $80x+40y+\delta l = +0.09$ | 48 | $+0.42$ |
| 13 | $100x+32y+\delta l = +0.71$ | 56 | $-0.22$ |
| 14 | $120x+27y+\delta l = +0.65$ | 16 | $-0.16$ |
| 15 | $147x+22y+\delta l = +0.56$ | 48 | $-0.07$ |
| 16 | $203x+15y+\delta l = +0.27$ | 26 | $+0.25$ |
| 17 | $277x+11y+\delta l = +0.34$ | 31 | $+0.25$ |

Proceeding to solve these by the method of least squares, I find

$$6636741\,x + 2629857\,y + 54905\,\delta l = 34428{\cdot}67$$
$$2629857\,x + 18102512\,y + 84176\,\delta l = 135055{\cdot}82\,;$$

whence

$$x = +0.00237 - 0{\cdot}00682\,\delta l$$
$$y = +0{\cdot}00711 - 0{\cdot}00366\,\delta l.$$

If

$$\delta l = +0''{\cdot}156 \pm 0''{\cdot}102,$$

as found from the observations of circumpolar stars (assuming that the Greenwich latitude requires no correction), then we have

$$x = +0{\cdot}00131 \pm 0{\cdot}00094$$
$$y = +0{\cdot}00654 \pm 0{\cdot}00077.$$

Therefore, by making use of all the available stars observed at Melbourne during the period 1871–1875, we find, for stars south of the zenith, that the adopted refractions should be diminished by

$$0{\cdot}00474 \times \text{Refraction};$$

whilst from the observations of stars north of the zenith it appears that the adopted refractions should be diminished by

$$0{\cdot}00654 \times \text{Refraction}.$$

It is evident that, so far, we have no reason to conclude that the constant of refraction is different in different directions; as of course, from the nature of the case, if we assume that the factors are, or may be, different, we are sure to get results differing to some extent. In fact, Mr. Stone found differences fully as great as these in his discussion of the Greenwich refractions from North and South stars.

It may be remarked in passing that the value of $x$ found above indicates that if the correction had not been applied to the Greenwich thermometer readings, the resulting correction to the adopted refractions would have been practicably insensible. So that, as Mr. Christie has pointed out, as far as 80° Z.D. Bessel's Refractions accurately represent the Greenwich observations, when the thermometer reads about half a degree too high.

Suppose now that we reject all stars which pass the meridian at or below 85° Z.D. Then the normal equations derived from the observations of circumpolar stars become

$$380\,x + 67087\,y = 191{\cdot}93$$
$$67087\,x + 13652133\,y = 38305{\cdot}52.$$

From these equations I find

$$x = +0''.073 \pm 0''.218$$
$$y = +0.00245 \pm 0.00115.$$

If $y$ were without error, the probable error of $x$ would be $\pm 0''.085$. The sum of squares of residuals, taking the weights into account, is 26·14.

We see, therefore, that the correction to the assumed co-latitude has changed sign, and the factor for correction to Bessel's Refractions is about half what it was before.

Proceeding in the same way with the North stars I find

$$6636687\,x + 2616843\,y + 54887\,\delta l = 34334.71$$
$$2616843\,x + 14966138\,y + 79838\,\delta l = 112411.46;$$

therefore

$$x = +0.00237 - 0.00662\,\delta l$$
$$y = +0.00710 - 0.00418\,\delta l.$$

The value of $y$ derived from the comparison with Greenwich therefore remains the same as when all the stars were used, provided the same value of $\delta l$ is substituted. If, however, we use the new value of $\delta l$, viz.

$$-0''.037 \pm 0''.109,$$

we find

$$y = +0.00725 \pm 0.00067.$$

The factors derived from North and South stars are now discordant to a considerable extent.

If we introduce into our normal equations only results deduced from stars passing the meridian above 82° Z.D. this discordance is still more strongly marked. Thus from the circumpolars we have

$$366\,x + 60465\,y = 171.91$$
$$60465\,x + 10519927\,y = 28836.06.$$

The solution of these equations gives

$$x = +0''.334 \pm 0''.403$$
$$y = +0.00082 \pm 0.00221.$$

If $y$ be supposed to be without error, the probable error of $x$ becomes $\pm 0''.085$. The sum of squares of residuals is 22·87. The factor for correction of the adopted refractions is again much smaller than before; and, taking into account the magnitude of its probable error, practically unimportant.

For the North stars passing the meridian above 82° Z.D. we have

$$6635751\,x + 2547579\,y + 54731\,\delta l = 33927{\cdot}55$$
$$2547579\,x + 9840602\,y + 68294\,\delta l = 82281{\cdot}62\,;$$

whence

$$x = +0{\cdot}00211 - 0{\cdot}00642\,\delta l$$
$$y = +0{\cdot}00781 - 0{\cdot}00534\,\delta l\,;$$

or the value of $y$ is still the same, if $\delta l$ is the same. If

$$\delta l = -0''{\cdot}167 \pm 0''{\cdot}202$$

as found from circumpolar stars above 82° Z.D. at lower transit, then

$$y = +0{\cdot}00876 \pm 0{\cdot}00134.$$

The discordance between the values of $y$ North and South is therefore much increased.

If we proceed a step further and reject all stars below 77° Z.D. we find from the circumpolar stars actually a negative value for $y$; whilst for the North stars, compared with Greenwich the value still remains practically unaltered.

It appears, therefore, as the general result of this investigation, that when the very low stars are included, where of course the refraction comes in with greatest effect, we get a fair agreement between the corrections derived from North and from South stars; but as we go on omitting the lower stars, the discordance between the corresponding corrections on the North and South sides increases rapidly. It is evident, then, that there is a serious systematic error affecting the observations made on one side or other of the zenith. There is, however, no reason to suppose that this arises from a difference in the mean refractions, resulting from the circumstance of the meridian on one side being over the sea and on the other side over the land, and the atmosphere therefore being in a different state with regard to moisture, as has been supposed; for, *if this* were the true explanation, the discordance referred to ought at all events not to *diminish* as the lower stars are included, whereas I have shown that it diminishes rapidly until at last it becomes practically insignificant. The origin of the discordance is more probably some mechanical defect in the instrument, as Mr. Christie has suggested.

I may remark that in Mr. Stone's discussion of the Melbourne results 1863–1865 referred to above, all the stars used are above 82° Z.D., so that the discordance which he has found is borne out to a great extent by the results of this investigation.

It becomes now a question of interest to determine, as far as possible, on which side of the zenith the Melbourne N.P.D.'s are most correct. Although no great certainty can be arrived at

with the means of judging the question which are available to us, still I think it most probable that it is the stars on the north side of the zenith which are most affected by systematic error. For it will be remarked that the circumpolar stars give very much the same results as Main's exhaustive discussion gave for the Greenwich N.P.D.'s—that is, that Bessel's Refractions unaltered answer very well down to 82° Z.D.; from 82° to 85° Z.D. that the refractions of the *Tabulæ* appeared to require to be diminished by ·00230 × Refraction; and below 85° Z.D. that the refractions of the *Fundamenta* should be used diminished by ·00152 × Refraction, the refractions of the *Fundamenta* being equivalent to those of the *Tabulæ* diminished by ·00327 × Refraction of the *Tabulæ*. These results agree very closely with those found in this paper for the Melbourne circumpolar stars, and therefore I conclude that it is probable that the N.P.D.'s of these stars are substantially correct. And in fact the substitution of Main's corrections below 82° Z.D. gives smaller residuals than I have obtained from the solution by the method of least squares. For, applying these corrections and putting $y=0$, we get

$$x = +0''.474 \pm 0''.065,$$

and the sum of squares of residuals (the weights being taken into account) is only 24·96: in the former case it was 44·43.

If we attempt to determine the co-latitude from observations of circumpolar stars which pass the meridian above 82° Z.D. at the lower transit, assuming that the refractions of the *Tabulæ* are correct down to that limit, we find

$$x = +0''.470 \pm 0''.077,$$

and the sum of squares of residuals is 23·54: in the solution given above for these stars this quantity comes out 22·87, so that our assumption is satisfactorily borne out, considering the difficulty of separating errors of co-latitude and of refraction at the latitude of Melbourne. I should recommend therefore that, for the present, a correction of $+0''.20$ be applied to the co-latitude assumed in this volume, thus making

$$\text{Co-latitude} = 52^\circ\ 10'\ 6''.8;$$

and that the refractions of Bessel's *Tabulæ* be used unaltered, at all events down to 82° Z.D.

I understand that efforts are being made to obtain a new Transit Circle, more suited to the requirements of modern astronomy, for the Melbourne Observatory. Until we have a series of observations made with such an instrument, I do not think that we can approximate more closely either to the true value of the latitude, or to the value of the constant of refraction

required by the Melbourne observations, than I have done in the present paper.

I add here, for convenience of reference, the separate comparisons, both for circumpolars and for stars compared with the Greenwich Catalogue, of all stars which pass the meridian of Melbourne below 82° Z.D. observed in the years 1871–1875.

### I. *Circumpolar Stars.*

| Star's Name. | N.P.D. | Upper – Lower. | Number of Obs. Upper. | Lower. |
|---|---|---|---|---|
| | ° ′ | ″ | | |
| β Centauri | 149 46 | −0·06 | 7 | 5 |
| ε Argûs | 149 6 | +2·18 | 7 | 6 |
| η Argûs | 149 1 | +1·86 | 12 | 4 |
| ι Argûs | 148 45 | +1·96 | 8 | 7 |
| α Eridani | 147 53 | +1·14 | 6 | 11 |
| α Pavonis | 147 8 | +3·19 | 10 | 9 |
| ζ Aræ | 145 47 | +3·38 | 6 | |
| α Doradûs | 145 18 | +5·10 | 7 | 5 |

### II. *North Stars.*

| Star's Name. | N.P.D. | Greenwich – Melbourne. | Number of Obs. Greenwich. | Melbourne. |
|---|---|---|---|---|
| | ° ′ | ″ | | |
| δ Cygni | 45 11 | +1·91 | 19 | 5 |
| α Cygni | 45 11 | +1·95 | 48 | 13 |
| ξ Andromedæ | 45 8 | +5·28 | 3 | 3 |
| β Aurigæ | 45 4 | +0·77 | 16 | 6 |
| ψ Ursæ Majoris | 44 48 | +1·11 | 13 | 6 |
| α Aurigæ | 44 8 | +3·12 | 45 | 12 |
| τ Herculis | 43 23 | +0·46 | 23 | 2 |
| δ Persei | 42 37 | +2·55 | 5 | 5 |
| 51 Andromedæ | 42 1 | (+10·50) | 6 | 3 |
| ι Ursæ Majoris | 41 27 | +3·04 | 17 | 10 |
| α Persei | 40 36 | +6·73 | 37 | 7 |
| η Ursæ Majoris | 40 3 | (+12·81) | 77 | 4 |

The quantities enclosed within brackets have not been used in the present investigation. The above comparison is made with the Greenwich places as printed in the Nine-Year Catalogue.